CHAPTER 7

EXPERIMENTAL SEMANTICS

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7.1 WHAT IS EXPERIMENTAL SEMANTICS?

EXPERIMENTAL SEMANTICS is an emerging area of scientific investigation in cognitive linguistics. Its primary aim is to study how people understand and generate linguistic meaning in everyday communication. In experimental semantics research, language theorists first generate hypotheses that resonate to cognitive linguistics assumptions about linguistic meaning, especially the idea that meaning is characterized in terms of conceptualization, and then they test these hypotheses by conducting controlled experiments with human participants. In their experiments, they apply statistical methods to measure and quantify the way people produce and understand words, sentences, and gestures in varied situations and under varied conditions, and then they draw conclusions based on systematic patterns that emerge. Experimental semantics, which draws on methods used in the behavioral sciences, focuses on semantic processing, often as an emergent property of embodied experience. It differs from psycholinguistics in that it focuses on meaning, especially relative to claims made by pioneering cognitive semanticists, such as George Lakoff, Ronald Langacker, and Leonard Talmy.[1] The goal of this chapter is twofold: to provide an overview of experimental semantics and to consider implications of this line of research for linguistic analysis.

[1] For a basic introduction to psycholinguistics, see Harley (2008) and Traxler (2011). To review a vast range of psycholinguistics tools, approaches, and theories, see Spivey et al. (2012).

7.2 THE NEED FOR EXPERIMENTAL SEMANTICS

Our everyday interactions are rich with meanings that rapidly emerge and shift over time. Meaning is highly complex and can be difficult to explain or objectively define partly because it depends a great deal on context. A friend tells you about a hike he took in Yosemite. He reports, "We walked to Glacier Point on a trail that climbed over 3,000 feet up the side of a cliff!" When you hear the motion verb "walked", you infer motion that transpired from one point along a trail to another. However, when you hear the motion verb "climbed" you do not infer literal motion, but rather, linear extension (of the trail). In addition, when you see your friend lift his hand and make a zigzagging gesture that goes upward, you infer that the trail was windy. And when he stressed the final word, "cliff", you sensed fear or excitement. Even though you have never been to Yosemite and have never been on a hike yourself, your friend's description, which integrated literal and non-literal language, gesture, and informative prosodic cues, gave you a good understanding of what the hike was like.

We humans are good at creating and interpreting meaning in all sorts of situations, including spoken, signed, or written, formal or informal, familiar or unfamiliar, emotional or unemotional. What drives our ability to make sense of meaning across countless situations and circumstances? How is this ability linked to other human experience, including mental and physical? What methods are appropriate or most informative for studying the processing of meaning? Finding answers to these questions is what experimental semantics is all about.

In the glory days of generative grammar, semantics research was often viewed as "messy", unruly, or even unscientific. Linguistic analyses focused on the more structural aspects of language, especially syntax and phonology (see Crystal 2010). This is not to say that meaning was uninteresting to linguists back then. Many important bodies of research emerged at the time, including work on semantic primitives (e.g. Wierzbicka 1972), semantic frames (e.g. Fillmore 1976), formal semantics, including Montague grammar (Partee 1975), and computational approaches to semantics, including lexical-functional grammar (Bresnan 1982). The study of semantics radically changed with the introduction of cognitive linguistics in the early 1980s. Cognitive linguistics, especially cognitive semantics, vivified semantics research by linking linguistic form to mental processes, and by paying close attention to the conceptual and perceptual properties of language, including both lexical and grammatical form. Over the years, cognitive linguistics has greatly advanced our understanding of how meaning is created, categorized, and modified across an impressive range of phenomena, including anaphora, aspect, deixis, modality, and metaphor. Cognitive linguistics has also contributed informative analyses of diachronic processes, including grammaticalization (see Heine et al. 1991; Heine and Narrog, this volume).[2]

Cognitive linguists do not adhere to the view that language is autonomous. They contend that language recruits perceptual and cognitive processes, and that it is grounded

[2] For an insightful overview of the history of cognitive linguistics, including its emergence from dominant 20th Century linguistics, including the generativist tradition, see Nerlich and Clarke (2007).

in our everyday embodied experience. Cognitive linguists view meaning as conceptualization (see Langacker 1987; Lakoff 1987; Talmy 1983, 2000). They maintain that meaning is (1) perspectival, (2) dynamic, (3) encyclopedic, and (4) usage-based, characterizations that are not mutually exclusive (see Croft and Cruse 2004; Evans et al. 2006; Geeraerts 2006). "Perspectival" refers to the construal of a scene with an emphasis on viewpoint. The sentences, "The roof slopes downward" and "The roof slopes upward" objectively mean the same thing, but they are understood differently with respect to viewpoint. Similarly, "I loaned you my book" and "You borrowed my book" convey the same basic information, but transference is construed differently, specifically, in different directions (for discussion of construal and perspective, see Langacker 1987; Talmy 1983, 2000). "Dynamic" captures the way meaning evolves incrementally during processing. For example, in processing a non-literal sentence, such as "The mountain range goes from Mexico to Canada", the conceptualizer subjectively moves along the mountain range, from Mexico to Canada (see Langacker 2000, for discussion). "Encyclopedic" indicates that meaning includes world knowledge (Fillmore 1982; Lakoff 1987; Langacker 1987). When we hear "large" we know that it is a relative term. We make sense of it by recruiting world knowledge in all sorts of situations, such as "large freckles", "large campus", "large galaxy", "large issue", and "large time window". Finally, "usage-based" refers to what we have learned and implicitly know through countless interactions with linguistic form and use in the past. We know that "freckle" is a countable, regular noun (unlike "sheep" or "furniture"), and that it takes a plural marker, and we also know that it is an intransitive verb, as in "She freckles easily in summer" (Barlow and Kemmer 2000; Langacker 2002).

Early cognitive linguists spearheaded many exciting research programs related to the idea that cognition is connected to linguistic form. In doing so, they occasionally referred to psychological or neurological research to inform their claims. Yet many of the tools they used to analyze their data were inherited from mainstream linguistics. They often relied on introspection to determine whether linguistic forms were semantically acceptable. Despite an earnest attempt to connect linguistic form and mental processes, there was more interest in the characteristics of linguistic form than in the characteristics of linguistic behavior (see Gibbs 1996 for discussion). In recent times, however, cognitive linguists are becoming more interested in substantiating their claims with data from experiments. Some cognitive linguists are acquiring expertise in psychological methods, including hypothesis testing and experimental analysis. Others are collaborating with psychologists that have similar theoretical views. On the other side, psychologists are becoming more receptive to working with cognitive linguists. Some of the interest in collaboration was spawned by the first Empirical Methods in Cognitive Linguistics workshop (EMCL), held at Cornell University in 2003. The goal of the event was to bring together cognitive linguists and psychologists to share ideas and forge new lines of research on the representation, use, and interpretation of language. Many of the seminars and papers that were published in the EMCL volume discussed meaning (see Gonzalez-Marquez et al.2007).

There are many good reasons to conduct experiments on semantic content. Experiments can expand and constrain linguistic theory by providing new or additional insights that might otherwise be missed in linguistic analyses alone. Because experiments allow researchers to formulate testable hypotheses, they can be useful to validating (or

invalidating) claims. Experiments also allow researchers to tap into the more implicit or subtle mental processes that inform linguistics analyses of semantic content. Relying solely on introspection, which necessarily involves conscious processing, to evaluate semantic content is problematic, especially given that linguists' intuitions have been shown to deviate from those of non-linguists (see Spencer 1973) and even from those of other linguists (Gries 2002). (For discussion about why experiments are useful in the context of cognitive semantics analyses, see Gibbs 2007).

Despite the many benefits of conducting experimental semantics studies, there are some limitations. In planning experiments, researchers must generate a set of circumscribed hypotheses, and go to great lengths to ensure they are reducing "noise" and focusing on the main point(s) of interest. This requires a great deal of careful preparation, including creating a set of constrained stimuli (e.g. use only high frequency intransitive verbs, not transitive; use all third person singular forms for sentential subjects) and carefully selecting the type of participants who will volunteer for the experiment (e.g. use speakers of only one language; use right-handed adults between the ages of 18 and 22). [3]

7.3 METHODOLOGY IN EXPERIMENTAL SEMANTICS

Experimental semantics recruits methods from the behavioral sciences to study how people process meaning. Experiments include at least one experimental manipulation, and measure behavior that arises from the manipulation(s). For example, a researcher might present participants with the sentences: "The road goes all the way to New York" or "The road comes all the way from New York." In this case, the manipulation would be perspective (away, toward), and it would bias participants to think about a road that extends away or toward themselves. Right after presenting the sentence, the researcher might then ask participants do a seemingly unrelated task, for instance, answer a question that relates to the metaphorical construal of time to see whether and how spatial thinking influences temporal reasoning. The researcher would measure the extent to which the manipulation affected the thinking about time. The researcher also might incorporate other tools to further investigate the perspective and temporal reasoning. For instance, she might ask participants to view a photograph of a road right after reading the sentence about the road, and measure where they direct their visual attention.

Some experiments use a between-subjects design, in which participants are engaged in only one experimental condition. Other experiments use a within-subjects design, in which participants are in two or more conditions. There are advantages and disadvantages to each design (for discussion see Martin 2008, and Schweighert 2011). In some experiments, participants are presented with only one stimulus item (e.g. one sentence), and in others, with multiple stimuli (e.g. set of sentences). In general, it is advisable to use many items because it helps assure that conclusions are generalizable (see Clark

[3] For lively discussion of some of the problems that arise in conducting experiments on language use, see Clark (1997).

1973b). However, there is no right or wrong number of stimuli; the number depends on the research question and resources available.

Experimental semantics uses "online" methods and "offline" methods. Online studies measure behavior in real time, often in milliseconds. For example, in an online lexical decision task, participants might view items such as "hand", "thub", and "cherry" on a computer screen, and quickly indicate whether they are real words or not by pressing a "yes" or "no" button. In an online narrative comprehension task, they might read a sentence and quickly decide whether it relates to a short story that they had just read. Response times generally differ for many reasons (because of a participant's familiarity with a specific word, because of a word's frequency etc.), but in a controlled experiment where a linguistic phenomenon is systematically manipulated while other things are kept constant, response times can be used to draw inferences on linguistic processing.

In offline studies, behavior is not measured in real time. In that case, participants might read a paragraph and then leisurely answer questions, or read a sentence and generate a drawing that reflects their understanding of its meaning. Both offline and online approaches are informative, and both have advantages and disadvantages. Offline experiments are simple to set up and run, but incapable of pinpointing when and how processing unfolds in time (see Garrod 2006). Online studies can be work intensive and require other technical expertise, but they are well suited for investigating the dynamics of language processing.

7.4 SURVEY OF EXPERIMENTAL SEMANTICS

This section summarizes some experiments with relevance to cognitive linguistic claims about meaning. These studies were conducted by cognitive linguists or by researchers who view language grounded in embodied experience. Our discussion is organized according to the four dimensions of meaning discussed in 7.2.

7.4.1 Perspective and meaning

A large body of research in cognitive psychology bears on the idea that conceptualization, including perspective, is important to meaning. Psychological research on so-called "situation models" (also called "spatial mental models") indicated that people keep track of the protagonists, their actions, and the spatial layout of verbally described scenes (Bower and Morrow 1990; Morrow et al. 1989; Zwaan and Radvansky 1998). The results of some of this work bears on the role of perspective in processing language.

Horton and Rapp (2003) used a classic narrative comprehension task to show that people tacitly rely on perspectival information in processing linguistic meaning, especially information about whether entities are occluded or not in a spatial scene. In particular, they explored whether the mental accessibility of an entity mentioned in text is influenced by the visibility of a protagonist. In their study, participants read brief stories such as the following:

> Mr. Ranzini was sitting outside on his front stoop. He had lived on this block for over 30 years. Next door was a local playground for the children. Directly across the street was the mailbox that he used. As usual, Mrs. Rosaldo was taking her poodle for a walk. Suddenly, a large truck pulled up in front of Mr. Ranzini.

Each paragraph included a final sentence about a critical entity that was visible or not visible to the protagonist. In the not visible condition, the critical item could not be seen ("Suddenly, a large truck pulled up in front of Mr. Ranzini") and in the visible condition, the critical entity could be seen ("Suddenly, a man on a bike rode up in front of Mr. Ranzini"). After reading the paragraph, participants answered a question about the critical entity (e.g. "Was there a mailbox across the street?"). On average, responses to the question were quicker in the visible condition, suggesting perspective, in this case, occlusion of objects, implicitly figures into semantic processing.

Stanfield and Zwaan (2001) also conducted research that speaks to the role of perspective in conceptualizing meaning. In their experiment, participants read a sentence and then immediately after, viewed a picture of an object. The depicted object was either mentioned in the sentence, or it was not. The task was to simply verify whether the picture did or did not occur in the preceding sentence. The crucial experimental manipulation involves object orientation. For example, the sentence "Mary pounded the nail into the wall" implies that the nail is oriented horizontally, whereas the sentence "Mary pounded the nail into the floor" implies that it is in vertical position. Results show that participants were generally quicker to verify whether an image matches a sentence if the visually displayed orientation of the object (e.g. a vertical or horizontal nail) was consistent with the linguistically implied orientation. This suggests that participants were visualizing the scene and activating information about object orientation (see also Pecher et al. 2009). This pioneering study supports the notion that perspectival information, precisely, the orientation of an object, plays a vital role in meaning interpretation.

Other research using this approach has focused on conceptualized distance and its role in language understanding. In Winter and Bergen (2012), participants viewed pictures of either small or large everyday objects (e.g. small fire hydrant, large fire hydrant) right after reading sentences that implied a distal or proximal position, for instance, "You are looking at the fire hydrant right in front of you" and "You are looking at the fire hydrant from afar." Again, participants were asked to decide whether the displayed images related to the sentences. The results indicated that participants were quickest to make their judgment when large objects were paired with proximal sentences (e.g. large fire hydrant with "You are looking at the fire hydrant right in front of you") and when small objects were paired with distal sentences (e.g. small fire hydrant with "You are looking at the fire hydrant from afar"). The results showed that information about perspective, specifically, distance from the conceptualizer, sped up responses. These findings provided further evidence that perspective, in this case, distance, is used to interpret meaning.

Another experiment related to perspective was conducted by Brunyé et al. (2009). Participants first read sentences such as "You are slicing the tomato", "He is slicing the tomato" or "I am slicing the tomato", whose sentential subjects varied in terms of how person was marked (first, second, third person). Next, participants saw a picture of two human hands slicing a tomato. The viewpoint was internal, namely, from the back (as if the person who took the picture were doing the slicing) or external, namely, from the

front (as if someone else were doing the slicing). Participants then had to indicate whether the picture matched the sentence. The results showed that participants were faster to verify a picture with the internal perspective after reading a sentence with a second or first person sentential subject, and faster to verify a picture with the external perspective after reading a sentence with a third person sentential subject. These results clearly show that interpreting personal pronouns that are functioning as sentential subjects involves perspective. When participants read sentences with a first or second person pronoun, they were more likely to take an internal perspective, and when they read sentences with a third person pronoun, they were more likely to adopt an external perspective.[4]

7.4.2 Dynamicity and meaning

In recent years, behavioral experiments have generated much evidence to show that everyday thinking and reasoning involves mentally simulation. Simply stated, people naturally simulate, or, "re-enact" actions, objects, states, locations, and situations across all sorts of cognitive states and in all sorts of situations. They do this through "re-enactments" of past experiences and states, mental and physical (see Barsalou 1999, 2008a, 2008b, 2010). The implications of this work are far-reaching. Simulations play a prominent role in the understanding of abstract concepts (Barsalou and Katja Wiemer-Hastings 2005). They facilitate mechanical reasoning (Hegarty 2004; Schwartz and Black 1996; Schwartz and Black 1999). They figure into the formation of attitudes, moods, and other behavioral states that affect social interaction (Niedenthal et al.2005).

Mental simulations are also known to play a vital role in language processing. This is neither remarkable nor surprising given that our mental processes are anchored in our perceptual and motoric experiences that occur in our interactions in the physical world. We implicitly recruit this information to communicate, including how we interpret and produce meaning (see Barsalou 2008a; Bergen 2012, Feldman 2006; Gallese and Lakoff 2005, Gibbs 2006, Gibbs and Matlock 2008, Glenberg and Kaschak 2003; Glenberg and Gallese 2011; Zwaan 2004). Much of the research on simulation in language is consistent with the idea that language (and other human behaviors) is dynamic and emergent (see Spivey 2007; Spivey and Dale 2004).

Matlock (2001, 2004b) investigated whether simulation would generalize to the processing of figurative language. A set of narrative understanding tasks examined the comprehension of fictive motion sentences, such as "The highway runs along the coast" and "Road 49 crosses the desert". In English and many languages, such as Japanese, Swedish, Spanish, and Hindi, stationary spatial configurations are often described in terms of motion even though nothing objectively moves. For example, in "The highway runs along the coast", the highway does not actually move; instead, it linearly extends through space. Cognitive linguists, most notably Talmy (1983, 2000), have argued that such constructions evoke mental "movement" that transpires along the subject noun phrase referent (see also Langacker 1987; Matsumoto 1996). This is known as "fictive motion" but has also been called "virtual motion" and "abstract motion" (see Matlock 2004a, 2010, for discussion). In Matlock (2004b), participants read short stories about

[4] See Sato and Bergen (2013) for similar work in Japanese.

actual motion that had transpired through or across large spatial regions, such as deserts, parks, and valleys. At the end of each story, participants read a fictive motion target sentence, and made a speeded decision about whether the target sentence related to what they had just read. For example, they read about a man who was driving through a desert, and then read the fictive motion sentence, "The road runs through the desert". In one experiment, the stories varied according to terrain. In the cluttered terrain condition, the stories included information about hilly, bumpy, and rugged terrains, and in the uncluttered terrain condition, the stories included information about flat and smooth terrains. The results showed that participants were generally faster to make their decisions about fictive motion sentences when the terrain was uncluttered than when it was cluttered. Two other experiments in Matlock (2004b) found consistent results, in those cases, with short versus long distance travel information and with slow versus fast travel information. Critically, in all these experiments, target sentences that lacked fictive motion (e.g. "The road is in the desert") were processed at about the same speed regardless of what participants had read beforehand. Together, the results suggested that readers' interpretations of fictive motion included simulated motion along the paths they had conceptualized. The results provided evidence to support the idea fictive motion involves mentally construed "movement" and that it is subjective (see Langacker 1987; Matsumoto 1996; Talmy 1983, 2000). In light of dynamic construal in linguistic meaning, this work shows how fictive motion interpretation dynamically emerges according to current context, for instance, information about cluttered or uncluttered terrains (see also Matlock 2004a).

In follow up work by Matlock and Richardson (2004), participants viewed scenes on a computer screen while listening to descriptions of those scenes. The researchers were interested in seeing how fictive motion would influence eye movements. Each scene was a simple line drawing that had a vertical and a horizontal path or linearly extended object, for instance, a line of trees running vertically, and a road running horizontally. Each target sentence was a spatial description that did or did not include fictive motion, for instance, "The cord runs along the wall" or "The cord is on the wall". While participants viewed pictures and listened to the sentences, their eye movements were tracked and recorded by an eye-tracking device attached to the bottom of the computer screen.[5] The eye tracker made it possible to pinpoint exactly where and how participants directed their visual attention while processing the sentences. The results showed that participants spent more time viewing the region of the scene corresponding to the relevant path or linear object while listening to sentences with fictive motion. For example, participants spent more time looking at the region of the screen that displayed the cord while listening to "The cord runs along the wall" than they did while listening to "The cord is on the wall".

A follow-up study by Richardson and Matlock (2007) used similar visual and verbal stimuli. Participants listened to a sentence that did or did not include fictive motion, such as "The road runs through the valley" or "The road is in the valley", after listening to a one-sentence terrain description, such as "The valley is covered with dust" or "The valley is covered with ruts". In each case, the terrain description contained information that implied relatively easy or difficult movement (e.g. dust versus ruts). Next,

[5] Eye tracking allows researchers to measure where and when eye fixations occur in the time course of processing visual and linguistic information. For comprehensive background, see Tanenhaus and Spivey-Knowlton (1996), Henderson and Ferreira (2004), and Richardson et al.(2007).

participants viewed a scene (e.g. valley). The results revealed that terrain information affected eye movement patterns with sentences that included fictive motion, but not with sentences that did not include fictive motion. Participants in this experiment consistently allocated more visual attention to paths or linearly extended objects (e.g. roads) after listening to information about difficult terrain (e.g. ruts in a valley) than after listening to information about easy terrain (e.g. dust in a valley).

These eye-tracking studies provided evidence to support the hypothesis that fictive motion includes dynamic construal in terms of mentally simulated motion. Other experiments discussed in this chapter also support the idea that meaning is dynamic. In Horton and Rapp (2003), the way people answered questions about perspective involved simulating the protagonist's viewpoint, and in Stanfield and Zwaan (2001), the way they answered questions about whether pictures and sentences matched involved simulating information about the orientation of objects. Together, these experiments show how the understanding of meaning depends on the narrative context, and how meaning is dynamically construed in relation to both current and preceding context.

7.4.3 Encyclopedic knowledge and meaning

The encyclopedic aspect of meaning emphasizes the role of world knowledge on linguistic processing. A study conducted by Zwaan et al. (2002) beautifully exemplifies this characterization of meaning. The study used a sentence-picture matching task, where participants either read sentences such as "The ranger saw the eagle in the sky" versus "The ranger saw the eagle in its nest". These two sentences describe not only two different spatial positions of the eagle (the sky or the nest), but they also imply two different shapes of the eagle associated with these spatial positions. An eagle in the sky most likely has its wings extended, but an eagle in its nest most likely has its wings folded down. This study showed that participants were generally quicker to respond to an eagle with wings folded down after reading about the eagle in the nest; and they were quicker to respond to an eagle with wings expanded after reading about the eagle in the sky. With respect to the current discussion, this experiment highlights a crucial aspect of meaning that is central to cognitive linguistics, namely, that meaning depends on or emerges from world knowledge. In this case, world knowledge dictates the inference that the wings are either extended or folded down and this world knowledge drives the understanding and simulation of the described scene.

Another experiment that demonstrates the influence of encyclopedic knowledge on linguistic meaning was conducted by Spivey and Geng (2001). Participants looked at a blank computer screen while listening to short stories about people, events, and objects. Participants' eye movements were recorded using an eye-tracking device. Each story emphasized information that "unfolded" or moved in different directions: upward, downward, rightward, leftward. For example, the downward story was

> Imagine you are standing at the top of a canyon. Several people are preparing to rappel down the far canyon wall across from you. The first person descends 10 feet before she is brought back to the wall. She jumps again and falls 12 feet. She jumps another 15 feet. And the last jump, of 8 feet, takes her to the canyon floor.

A control condition story was included that emphasized no direction. One of the main results was that story direction biased participants' eye movements. For instance, listening to downward movement led to more downward eye movements on the blank screen. The results show that when people are processing linguistic information to mentally create a situation model, they deploy some of the same perceptual-motor mechanisms that would also be used to view the actual situation. The results nicely demonstrate the primacy of encyclopedic knowledge in language processing. People naturally tap into what they know about the world to make sense of linguistic input. This includes knowing about orientation and direction in particular contexts and situations, for instance, knowing that canyon walls are vertically oriented, and that rappelling is a downward movement that happens in canyons. The beauty of this experiment is that it yielded a purely embodied effect: Participants' eyes moved in systematic, predictable ways even though they were unaware their movements were being measured.

7.4.4 Meaning based on usage and experience

A growing body of experimental semantics research supports the idea that meaning depends on usage and experience. From birth we start acquiring linguistic patterns, lexical and grammatical, that become entrenched in our everyday language use (Tomasello 2003). Over time, even the more diffuse patterns we repeatedly encounter become associated with particular meanings, sometimes with powerful consequences for reasoning about actions and states in the world. In this section, we discuss a number of experimental semantics studies that have been conducted on grammatical aspect and how it influences thought about actions and states in everyday reasoning. We focus on perfective and imperfective aspect.

In psychological research on spatial mental models, Morrow (1990) investigated the role of aspect in memory of scene descriptions. Participants first studied the layout of a house, and then read a short story about a person who went from one location to another in the house. Sentences in the passage included motion verbs (e.g. "walk") that were marked with either imperfective or perfective aspect[6] in addition to a source location (e.g. "kitchen") and a goal location (e.g. "bedroom"), as in "John was walking from the kitchen to the bedroom" or "John walked from the kitchen to the bedroom". Participants were later queried about the location of the protagonist, who was often remembered to be between the source and goal locations after they had read imperfective descriptions, but in the source location after they had perfective descriptions. These results suggest that grammatical aspect can influence memory: Imperfective draws attention to the unfolding of the event, and perfective, to the resulting phases of the event (for other research on memory and aspect, see Magliano and Schleich 2000).

Anderson et al. (2008) also investigated aspect in scene descriptions. In doing so, they developed a novel use of mouse-tracking.[7] Sitting in front of a computer, participants

[6] English lacks a true perfective versus imperfective contrast. For the purposes of this discussion, it uses simple past and past progressive to achieve similar effects with past events. This of course also depends on verb semantics, including telicity and others factors.

[7] In mouse-tracking, participants move a computer mouse to a specific location on a computer screen (e.g. an object in a scene) while listening to linguistic input. One obvious benefit of this approach is immediacy:

viewed pictures of paths that always extended from the bottom to the top of the screen. Each path had a start point and an end point. Next to the picture was a small silhouette character, for instance, a man depicted as jogging (e.g. slightly bent legs and arms). For each path, participants listened to a sentence whose first clause described the character's movement to the destination. That first clause featured a motion verb with imperfective aspect, as in "Tom was jogging to the woods and then stretched when he got there" or perfective aspect, as in "Tom jogged to the woods and then stretched when he got there". When the motion description was played, participants would mouse-click the character and drag it into the scene and along the path to match the description. The results showed that participants generally moved the character along the path more slowly while they were processing imperfective input as opposed to perfective input. The results of these studies suggest that imperfective aspect reflects greater attention to the ongoing process of motion (for compatible findings, see Madden and Zwaan 2003; Anderson et al. 2010).

Huette et al. (2012) used eye-tracking to investigate the processing of grammatical aspect in narratives. Participants listened to stories that included imperfective sentences (past progressive), or to stories that included perfective sentences (simple past). The results showed that participants' eyes fixated more briefly and were distributed across a wider area of the screen while participants were listening to imperfective stories (versus perfective stories). This result is in line with the idea the imperfective triggers an event-internal perspective (leading to a wider distribution) where actions are simulated in great detail (leading to more eye movements). This experiment, which mirrors passive listening situations in everyday communication (e.g. listening to a story or a lecture), shows that eye movements during narrative comprehension are altered by grammatical aspect alone.

Fausey and Matlock (2011) used surveys to investigate grammatical aspect, especially whether imperfective and perfective information would lead to different inferences about the amount of action conceptualized in a given time period. In the study, participants read a short story about a senator who exhibited undesirable behavior in the past, and then answered questions about this behavior. When the senator's undesirable actions were described using imperfective aspect, such as "was taking hush money from a prominent constituent", participants were more confident that he would not be re-elected than when his actions were described with perfective aspect, such as "took hush money from a prominent constituent". Imperfective aspect also resulted in higher dollar estimates when participants were asked how much hush money was taken by the senator. The results of this study suggest that people focus on the ongoing nature of a situation, which can then lead them to infer that more actions took place. For a politician seeking re-election, this has deleterious effects.

Matlock et al. (2012) investigated the influence of grammatical aspect on how people report car accidents. Participants viewed videos of car accidents and were asked to re-tell what they had seen. The query was either "What happened?" (perfective) or "What was happening?" (imperfective). When responding to the imperfective question, participants produced more reckless driving language, such as "He tried to cut off the car in front of him," and more iconic gestures, such as a hand movement to show the car cut somebody off. Together, the results show that questions framed with imperfective information can

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The continuous stream of data allows researchers to pinpoint exactly when and how changes arise over the time course of a mental event (see Freeman et al.2011, for discussion).

cause greater attention to action details than questions with perfective information (for consistent findings with gesture, see Duncan 2002; Parrill et al. 2012).

7.5 EXPERIMENTAL SEMANTICS AND NON-LITERAL MEANING

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In section 7.4 we discussed experiments with literal language, and with fictive motion language. Here we discuss experimental semantics research on non-literal language, especially metaphor.[8] Conducting experiments on metaphor is valuable because it figures into everyday thought and language. Cognitive linguists have convincingly argued that non-literal language is not secondary or derivative of literal language. It is equally prevalent and worthy of analysis (see especially Gibbs 1994b; Katz et al. 1998; Lakoff and Johnson 1980, 1999; Lakoff and Turner 1989).

7.5.1. Metaphor

Metaphor has been extensively studied in cognitive linguistics, beginning with Lakoff and Johnson's (1980) seminal work on conceptual metaphor. Cognitive linguists agree that metaphor is far more than a literary device or way of talking or writing; metaphor appears in everything from musical lyrics, such as "You walked across my heart like it was Texas" (in the country western song "Coca Cola Cowboy") to statements in everyday conversation, such as "He walked me through the agenda right before the meeting." Moreover, as purported by Conceptual Metaphor Theory (Lakoff 1980; Lakoff 1987; Gibbs 1994), metaphors structure the way we conceptualize abstract ideas or entities, such as love, emotions, time, and math.

Many experiments have been conducted on conceptual metaphor since the emergence of cognitive linguistics. Raymond Gibbs and his students paved the way for using experimental methods in the study of non-literal meaning. To start with, they conducted many experiments designed to tap into the conceptual underpinnings of idiomatic expressions (e.g. Gibbs 1992; Gibbs and Nayak 1991; Gibbs et al. 1997; Gibbs et al. 1989; Gibbs et al. 1989; Nayak and Gibbs 1990). Some of this work examined how conceptual properties of metaphor relate to the understanding of idiomatic expressions which some language theorists had characterized as "dead metaphors" that are frozen and unanalyzable (for discussion, see Gibbs 1992; Nunberg et al. 1994). In one early offline study on metaphor idioms by Gibbs and O'Brien (1990), participants were presented with idiomatic expressions, such as "Spill the beans" and "Let the cat out of the bag". They were asked define them and form a mental image of each. Next they were asked

[8] Although we are discussing non-literal language in this section, we do not endorse a hard distinction between literal and non-literal language. For discussion of the gradation between literal and non-literal language, see Coulson and Matlock (2001), Gibbs (1994a), and Rumelhart (1979).

questions about the mental images, such as "What caused the action to happen?" and "What happens as a result of the action?" Responses across the participants were very consistent; for instance, in describing the image that came to mind with "Spill the beans" and "Let the cat out of the bag," many participants described a container that opened or tipped over and contents were forcefully revealed. In brief, the results suggested that conceptual metaphors, such MIND IS A CONTAINER and IDEAS ARE ENTITIES, naturally structure people's understanding of idioms and motivate their meaning.

In later work that used online measures, Gibbs et al. (1997), found consistent results. Participants in their study read short stories that ended with an idiom, a literal paraphrase, or an unrelated statement, e.g. "John blew his stack", "John got very angry", or "John dented the door". Participants had to push a button indicating that they had understood the sentence that they had just read. Right after that last sentence, participants read a letter-string that did or did not relate to the metaphor related to the idiom. For example, for ANGER IS HEATED FLUID IN A CONTAINER, they read "heat" (related) or "lead" (not related). Participants then had to quickly decide whether that letter-string was a meaningful word in English. One of the main results was that participants were generally faster to make lexical decisions to metaphorically related target words (e.g. "heat") after just having read the corresponding idioms. They were relatively slower in responding to literal paraphrases (e.g. "John got very angry") or control phrases (e.g. "John dented the door"). With this example, it is clear that people are immediately interpreting information related to the conceptual metaphor ANGER IS HEATED FLUID IN A CONTAINER.

For decades or even centuries, scholars interested in the conceptual properties of language or mental experience have argued that our sense of time and space are intimately related. Everyday language reflects this close connection in the prevalence of statements such as, "Summer vacation is coming our way", "Halloween is before Thanksgiving", and "The weekend is right around the corner". Lakoff and Johnson (1980) proposed the conceptual metaphor TIME IS SPACE, and many other cognitive linguists have discussed it at length, including Evans (2004) and Radden (1996, 1997). Two complementary ways of instantiating TIME IS SPACE have been discussed by Clark (1973a), Lakoff and Johnson (1980), Moore (2006) and others: With an "ego-moving" perspective, the person construing time experiences "moving" through time. This is exemplified in statements such as "We are quickly approaching the deadline" and "We raced through the morning." With a "time-moving" perspective, the person construes time as an entity that moves relative to other entities, most notably, relative to the subject noun-phrase reference of the sentence. This is exemplified in statements such as "The deadline is quickly approaching us" and "The morning raced past us."

Boroditsky and Ramscar (2002) investigated how people interpret this metaphorical distinction in English. In one of their offline experiments, participants first read the following query, which was adapted from earlier work by McGlone and Harding (1998):

> "Next Wednesday's meeting has been moved forward 2 days. What day is the meeting, now that it has been rescheduled?"

This "move-forward" question is ambiguous in that "Monday" or "Friday" are both viable answers. The key phrase here is "moved forward". If an ego-moving perspective is adopted, in which the person is construed as "moving" forward through time, "Friday" is likely to be the answer (because the meeting would be interpreted as two days after

Wednesday). However, if a time-moving perspective is adopted, in which time is construed as "moving", "Monday" is likely to be the answer (because the meeting would be interpreted as two days before Wednesday). Before reading this question and thinking about whether the meeting would be "Monday" or "Friday", participants were encouraged to think about themselves moving toward a particular position in space (ego-moving condition) or about an object moving toward themselves (time-moving condition). The results of this and other experiments they ran showed that participants were more likely to provide a "Friday" response after being primed to think about themselves moving forward, but more likely to provide a "Monday" response after being primed to think about something else moving toward them. In this case, varying information about the source domain (direction of movement) differentially influenced how people metaphorically construed time (see also Núñez et al. 2006; Teuscher et al. 2008).

Matlock et al. (2005) followed up with a similar experiment using the "move-forward" question. Their participants were encouraged to think about a more subtle, metaphorical type of motion. Participants read sentences that included fictive motion, such as in "The highway runs along the coast", or sentences that did not include fictive motion, such as in "The highway is next to the coast". As discussed above, fictive motion includes mentally "moving" or "scanning" along a path or linearly extended object. For instance, in interpreting a sentence such as "The highway runs along the coast" people simulate motion along some portion of the highway (see Matlock 2004a; Matlock and Bergmann to appear). Next, participants were asked to draw a sketch that represented their understanding of the sentence they had read, and then to answer the "move forward" question used in Boroditsky and Ramscar (2002) (see above). Participants who were in the fictive motion condition generated more "Friday" responses, and those in the non-fictive motion condition generated about the same number of "Friday" and "Monday" responses.[9] In addition, participants in the fictive motion condition also drew more motion elements (e.g. bicyclists, joggers) in their sketches than did participants in the non-fictive motion condition (reported in Matlock et al. 2004). Another experiment by Matlock et al. (2005) included a manipulation of direction. Participants in that study read a sentence with fictive motion that implied direction toward or away from the body, either "The road comes all the way from New York" or "The road goes all the way to New York" before drawing a picture and answering the "move forward" time question. The results revealed more Friday responses with the "goes to" fictive motion sentences, and more Monday responses with "comes from" fictive motion sentences, showing how direction of fictive motion can influence temporal reasoning. The results of these experiments on fictive motion demonstrate that even fictive motion, a diffuse non-literal type of motion, can influence metaphorical thought about time.

In the studies described above, information relevant to the source domain was manipulated to yield differences in the understanding of target domain information. For instance, in Boroditsky and Ramscar (2002) and Matlock et al. (2005), thought about motion systematically influenced thought about time. In experimental semantics research on metaphor, the link between source domain and target domain is explored in many

[9] Ramscar et al. (2010) replicated these results in a follow-up study in which participants did not draw a picture.

ways, with a vast range of source domains and target domains. Wilson and Gibbs (2012) is another study that was designed to test how the source domain information would affect target domain interpretation. In that study, participants performed a physical action, such as pretending that they were grasping an object immediately before reading a metaphorical phrase, such as "Grasp a concept". Next they pressed a button to indicate that they had understood the meaning of the phrase. Some of the actions and phrases were compatible, such as the action of grasping and "Grasp a concept", and some were not, such as the action of chewing and "Grasp a concept". In a second experiment, participants followed the same procedure, but in that case, they imagined doing the actions instead of actually performing them. In brief, the results showed that both real and imagined body movements that were related to metaphorical phrases facilitated people's immediate comprehension of those metaphorical phrases. These results provide good evidence that physical actions, or even imagined actions, can enhance people's embodied, metaphorical construal of concepts. The finding that physical actions facilitated the understanding of corresponding metaphors shows that conceptual metaphors such as IDEAS ARE OBJECTS are grounded in our diverse embodied experiences in the world.

Some experiments on metaphor approach the source domain and target domain differently. In a study on SOCIAL DISTANCE IS SPATIAL DISTANCE by Matthews and Matlock (2010, 2011), participants first read about a person who went through a park and passed by friends or strangers, and then viewed a picture that showed stick figures that represented either friends or strangers. The participants were asked to draw a line representing the route the person took through the park. The results revealed that participants drew lines closer to the stick figures when they believed they were friends. The results suggest that people implicitly think about closer distance with friends than they do with strangers. Here information about the target domain (social distance, as manifested through information about friends vs. strangers) transferred to the source domain (space, as manifested through line drawings). Other experimental evidence has found that manipulating the target domain affects responses related to the source domain. For example, emotional state, the target domain of such metaphors as HAPPY IS UP and SOCIAL WARMTH IS PHYSICAL WARMTH, has been shown to affect the perception of vertical space (see Meier and Robinson 2004) as well as room temperature (Zhong and Leonardelli, 2008), the respective source domains. Likewise, in Gibbs (2012), manipulating linguistic information about relationships using the LOVE IS A JOURNEY metaphor affected behavior in the relevant source domain, specifically, walking speed and distance. Even though some research finds that source domain knowledge always affects target domain, but not the other way around (e.g. Casasanto and Boroditsky 2008), more and more experimental studies implicate a bidirectional mapping between source and target domain (see discussion in Winter and Matlock 2013). This is one area where experiments might not just confirm already existing linguistic theories, but where they suggest re-conceptualizing key ideas, such as the proposal that metaphorical understanding is asymmetrical, going *only* from source to target domain.

7.6 FUTURE DIRECTIONS

Experimental semantics is a burgeoning area that will take new directions the decades to come. We have discussed some experiments that demonstrate its value to linguistic analysis. In doing do, we focused on experiments that are grounded in or that resonate to claims and developments in cognitive linguistics. Because of limited time and space, we did not discuss experiments that draw on theoretical notions from the more formal areas of linguistics. Some of the questions and claims in formal linguistics have also been addressed, often in psycholinguistics or neurolinguistics (e.g. Papafragou and Musilino 2003; Pylkkänen 2008). In this section, we briefly discuss additional approaches and directions that hold promise for the future of experimental semantics.

In recent years, cognitive neuroscience has provided a large body of evidence to support the idea that semantics is grounded in our perceptual and motor systems, and that understanding meaning involves mental simulation by engaging the sensorimotor system. For example, Hauk et al. (2004) used fMRI (functional magnetic resonance imaging) to monitor the brain activity of participants while they read action words related to the face, arm, and leg (such as "lick", "pick", and "kick"). The results indicated that areas of the brain associated with executing the very actions described by these words showed activation, in line with the notion that understanding involves "re-enacting." Another fMRI study, Tettamanti et al. (2005), investigated the connection between processing action sentences (e.g. "kick the ball") and areas associated with planning and executing those physical actions (e.g. the brain area responsible for foot actions). Participants in their study listened to sentences that described actions performed with the mouth, the hand, or the leg. The results showed that sentences that describe physical actions (e.g. "I kick the ball") activate motor areas associated with planning and executing the corresponding movements, but sentences that do not describe physical actions (e.g. "I appreciate sincerity") do not.

Cognitive neuroscientists have also investigated the processing of non-literal language, including fictive motion. Using fMRI, Saygin et al. (2010) monitored brain activity while participants read three types of sentences: actual motion, such as "I drove from Modesto to Fresno"; no motion, such as "Modesto and Fresno are in California;" and fictive motion, such as "The highway runs from Modesto to Fresno". Their results showed that actual motion sentences activated brain areas associated with visual processing of motion more than no-motion sentences, and that fictive motion sentences elicited more activation than no-motion sentences, but less than actual motion sentences. These results support the idea that people simulate motion with fictive motion, and that this mirrors actual motion. (For a review of neuroscientific methods and cognitive linguistics, see Bergen 2007, and Coulson 2007).

Far more experimental semantics work could be done on semantics in the production of natural discourse. Especially interesting is how gestures vary across different circumstances and what they mean for semantic processing. Gestures are known to help with lexical access during speech production (e.g. Rauscher et al. 1996). They are also known to reveal many useful insights into how language is conceptualized (McNeill 1992), including metaphorical language (Cienki and Müller 2008). They are also known to have benefits for both the listener and the speaker (i.e. the person generating the gesture). For instance, gestures can help plan what is to be said or done next, especially useful in situations involving coordinated action (Clark and Krych 2004). Gestures are also known to be in line with linguistic practices within a culture and across cultures. For

instance, in the Aymara culture, speakers gesture about the future as if it were behind them, e.g. by pointing over their shoulder (see Núñez and Sweetser 2006), which is corresponding to the way speakers talk about the future as metaphorically being behind oneself. The way people gesture in a given culture also tends to be consistent with the linguistic patterns used by that culture, such as whether they are speaking a verb-framed language or a satellite-framed language (see Kita and Özyürek 2003).

Corpus studies are a central part of linguistic analyses, and in recent years they have been improved by the development of highly sophisticated quantitative tools. Corpus analyses, even those that involve hypothesis testing, are not considered true experiments, in part because they do not randomly assign human participants to various conditions (see Martin 2008 for discussion of true experiments). However, the results of corpus analyses can be combined with the results from experimental studies (see Gilquin and Gries 2009). In the coming years, we will no doubt see more and more corpus analyses conducted in tandem with experiments (for discussion, Gries et al. 2005).

Finally, in an era of big data and immediate access to the Internet, linguistic data is now readily available to for a wide range of purposes. Google and other robust search engines have changed the ways we approach and implement linguistic analyses. The Internet offers endless opportunities for doing fast, low-cost experiments on people from diverse linguistic backgrounds. Crowd-sourcing tools, such as Amazon's Mechanical Turk, enable researchers to conduct experiments with hundreds of participants from all over the world within a matter of hours (see Sprouse 2011; Gibson et al. 2011). It will be fascinating to see where experimental semantics goes in the next 25 years.

7.7 CONCLUSIONS

Despite centuries of scholarly debate about what meaning is and how it is represented, little is known about how it is processed. Even less is known about how it influences human thought and behavior. This chapter discussed experimental semantics, a new, emerging area of research whose mission is to study how people understand and generate meaning in various linguistic contexts. Special attention was given to studies that are in line with claims from cognitive linguistics, especially cognitive semantics. A wide range of experimental tools were covered, including eye-tracking and narrative understanding tasks. Many also have direct relevance to studies in pragmatics.[10] Each of the tools discussed here can be adapted to test a wide range of linguistic phenomena in any spoken language, and some could be adapted to study signed languages. Each tool is useful and valuable in its own right for linguistic analyses.

Acknowledgements

We thank Amy Newsam and Paul Maglio for assistance with this manuscript. We are grateful to the Editors of this volume.

[10] On our view, there is substantial overlap between semantics and pragmatics.

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